Keynote Address by

Dr. James C. Fletcher

Administrator

National Aeronautics and Space Administration

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Utah Section

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Salt Lake City, Utah

February 21, 1974

[illegible] – USGS
Aquifers

It is a great pleasure to be here today, and especially to be welcomed here in Salt Lake City by the Chairman of the Committee on Aeronautical and Space Sciences of the United States Senate.

As you can imagine, Senator Moss and I work closely together in Washington. We meet quite often, but not on the same platform as here today. When the Committee has hearings, the Chairman and the other Senators sit up there on a dias, and my colleagues and I from NASA sit down in front at the witness table.

We always know we are going to get some searching questions from Senator Moss, but we always know, too, that his questions will be fair ones, and that his aim is to separate the wheat from the chaff and to make sure that the public is going to get a good return on its investment in aeronautical and space research and technology. That, of course, is my aim, too. And when we go before the Senate Committee on Aeronautical and Space Sciences, we try to make sure that it is only with wheat, no chaff. When we do that we get along very well with Senator Moss.

I fully share Senator Moss' belief in the desirability and wisdom of maintaining a strong national effort to advance technology, and I deeply appreciate the support he has given, and is giving, to NASA programs in space and aeronautics.

I have with me today a particularly striking enlargement of one of the more than one hundred thousand images produced by ERTS-1. It happens to be of the Salt Lake City area, and it happens to show how versatile and useful the ERTS reports can be. We had intended to send this to Senator Moss in Washington, but when I learned that we would both be on the same platform here today, I thought this would be the appropriate time and place for the presentation. I would like to see this picture become well known throughout Utah, as a symbol of the Space Age and how space technology is beginning to serve mankind.

Presentation to Sen. Moss

Now let us take a closer look at what the ERTS program is, and what it can lead to.

The strange sounding name (strange until you get used to it) stands for Earth Resources Technology Satellite. The word "technology" in the name is important; it means this is an experimental program, not yet ready for, or intended for, routine operations.

When we talk about the ERTS program we are really talking about many things: Desc. of ERTS

-- We are talking, first of all, about an ~~amazing~~ precision spacecraft in an ~~amazing~~ precision orbit.

-- We are talking about new kinds of instruments that make images of the Earth from high altitudes that are quite different from aerial photographs, and more useful in many ways.

-- We are talking about new ways for feeding the outputs of these imaging instruments to computers that give us the specific and relevant information we want and discard the rest.

-- Finally, and most important, we are talking about a community of users, and potential users. If you are not a user yet, but work with maps, I am sure you are about to become one.

To make a long story short, ERTS has become a Space Age word that stands for a new way of seeing the Earth and using what we see.

The ERTS Spacecraft

The ERTS spacecraft is a remarkable piece of Space Age machinery. It is small. It weighs less than a ton. But it is crammed with instruments. It has gyroscopes and small rocket motors and a supply of rocket fuel to keep it stabilized and its instruments always pointed toward Earth. It produces its own electric power from its wing-like solar panels. And it travels at more than 14,000 miles an hour, day after day, month after month, using no fuel at all but the Earth's gravitational pull.

ERTS-1 was designed for one year of useful life. But we celebrated its first birthday in July of last year and it is still going strong. We have a second ERTS spacecraft that will be ready for launch early next ~12 mos, year, but we very likely will hold it in reserve if ERTS-1 is still functioning as well as it is now. We have some experimental weather satellites similar to ERTS in design that have worked for four years.

The ERTS Orbit

It is somewhat of a miracle that ERTS produces such precise data, but that is due in part to the orbit ERTS uses. Without its very special orbit, ERTS would not be worth much.

It is in what we call a Sun-synchronous orbit. It is a little like a plane flying west that seems to keep up with the Sun. ERTS orbits over the poles, but as it flies from north to south over the Sun-lit half of the Earth, it is actually headed 9.1 degrees west of south. And this heading is just enough to enable it to keep up with the Sun as the Earth turns eastward.

ERTS-1 crosses the Equator 14 times a day on its north-to-south course, and no matter where it crosses the Equator, it is always at the same time, about 9:30 a.m. local Sun time.

ERTS-1 does not run on standard time or daylight saving time, but on natural Sun time like our grandfathers used before the standard time zones were set. Sun time was not very satisfactory for running railroads, but it is good for running satellites that observe the Earth.

ERTS-1 comes back over the same track every 18 days, always at about the same time as before.

For example, it crossed the Salt Lake City area last Saturday at 11:38 Mountain Daylight Time. It will be back 18 days from then -- that will be March 6 -- and every 18 days thereafter, at about 11:38 MDT, until it runs out of the rocket fuel that keeps in precisely in position. (The time of crossing this area will vary slightly with the seasons of the year.)

10^{38} MST
(1 hr late)
9^{30} Eastern
time - probably
O.K. at Platte
Neb.

This uniform time that ERTS keeps is intriguing, but it is also very practical and very important to the job ERTS does.

If you have ever worked with aerial photographs, you know that pictures taken at different times of the day look quite different and are hard to match up because of the different Sun angles and the different way the shadows fall.

ERTS pictures always have the same Sun angles and shadows because they are taken at the same Sun time, on each 18-day pass, in every part of the world, year after year. It has been determined that mid-morning Sun angles are best for photo interpretation, so that is why 9:30 a.m. was picked as the time for ERTS to cross the Equator.

ERTS-1 is in a near-circular orbit about 570 miles high. It completes a trip around the Earth every 103 minutes. On each pass over the United States its instruments scan a strip 115 miles wide. The images are processed as squares, 115 miles on a side. Each ERTS image covers a lot of territory -- more than 13,000 square miles. About 600 ERTS images can cover the whole United States. And the job can be done in a few days, except where cloud cover interferes. But since ERTS comes back every 18 days, eventually we get images of every part of the United States free of clouds.

The U. S. Geological Survey has estimated that it would take 60,000 images from high altitude aircraft to assure the same coverage. But, of course, aircraft could not begin to do the same job, because lighting conditions would not be uniform and there would be long delays from start to finish. And there would be too much detail for most users to handle. 100/1

Moreover, ERTS images are unique and especially valuable because one image covers a whole region, or mountain range, or watershed, or metropolitan area, and we see things from the ERTS perspective that have never been seen before, with the best cameras or the sharpest eyes.

I should also make clear that Earth observations from space and aerial photography are not competitors. They complement one another. Aerial photography will always be needed for high resolution and for specific purposes in localized areas. Aerial photography and ground investigations will also be needed from time to time to help interpret or verify what the satellite images reveal.

The ERTS Sensors

You may have noticed that I keep referring to the products of ERTS as images, rather than pictures or photographs. There are no ordinary cameras aboard ERTS.

There are six different kinds of sensors we have tried out for Earth resources surveys from aircraft and spacecraft.

They are

-- Photographic film cameras

-- Television systems

-- Multispectral scanners

-- Thermal mapping scanners

-- Imaging radar systems

-- and Microwave radiometers

But ERTS carries only a television system (the Return Beam Vidicon) and a Multispectral Scanner. These two systems work in different ways but produce similar results.

The Multispectral Scanner on ERTS has four ~~sensors~~ channels. None of them pick up normal light as seen by the eye. One picks up radiation in the red color band, one picks up green, and two pick up different wavelengths of infrared radiation not visible to the eye.

Why are sensors operating at these special wavelengths more effective than an ordinary camera? It's a long story. I can give two easy examples.

Green light passes through water and is not reflected very much. But it is reflected strongly by sediment in the water. Therefore, sediment and other forms of pollution in rivers, lakes, and oceans may show up quicker in a sensor operating at the green wavelength.

You are probably familiar with the way infrared is used to identify vegetation in images from space. Healthy vegetation reflects infrared wavelengths very strongly, almost like snow reflects visible light to the eye. An expert, looking at infrared images from ERTS can tell whether a crop is healthy or not. Or he can spot forests that are under heavy attack by insects or disease. And by comparing how a field looks in the visible region of the spectrum with the infrared he can tell whether the crop is wheat or oats or beets and so on.

Some wavelengths are especially good for sharply delineating coast lines, others are best for measuring the depth of snow in remote mountain regions, others help the land use planner.

Serving the User

The main point I should make here is that spectral images from space are intended for specialists, for people who know how to use them, whether for regional planning, or prospecting for minerals, or for updating maps.

As I reminded you earlier, ERTS is an experiment. And hundreds of potential users around the world are cooperating with us to find out if and how ERTS data can be used in their special areas of interest and in their professions.

One of the things NASA is learning to do in the ERTS program is to provide the relevant data to the users quickly and in usable form. This means we must use computers to digest the vast amounts of electronic data coming in from ERTS and to produce specialized printouts for each class of user. For example, the man who is keeping track of snow cover may want frequent maps that show only the snow covered areas. Now white snow will not show up very well on a blank map. So he gets a printout that arbitrarily shows the snow as green -- dark green for deep snow and light green for light snow. When he gets used to the fact that snow is green, he has a valuable tool and has become one of the growing fraternity of spectral image users.

Well, that's just a quick glance at how ERTS and its sensors work. There is really nothing mysterious about them if you are familiar with the electromagnetic spectrum and if you accept the fact that whenever you look at any object there is more there than meets the eye -- more radiation being emitted or reflected than the human brain can use without special instruments.

If you are already working in this field, you probably know more about it than I do. If you are not yet working with multispectral images, I hope my remarks have stimulated your interest in learning more about them and how they are being used in the Space Age.

ERTS technology promises to be one of the most useful tools we can have to help monitor and combat pollution and manage Earth resources better. But this new tool did not come into being overnight. People at NASA and in the universities and in the aerospace industry have been working actively on the ERTS program since 1966. We have made extensive use of aircraft and ground controls to try out instruments and demonstrate new uses. And, of course, basic research in the new discipline of remote sensing has been going forward for decades.

USGS Prototype Satellite Gridded Image

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But the quality of ERTS images, from a mapper's point of view, has been surprising.

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They have just recently published and put on sale what they call an experimental prototype gridded image of the Upper Chesapeake Bay region, including Washington and Baltimore.

The image is about 15 by 15 inches. The scale is 1:500,000.

The USGS says: "This product is unique in that the actual ERTS image format was used rather than a conventional quadrangle format and the graticule and grid were fitted to the image."

The USGS points out that "preparing a map from the multispectral images of one scene is much faster and less costly than mosaic-ing several images on a conventional format."

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The Next Step -- Earth Observatories

Now we are getting ready for the next big step when ERTS experiments become routine operations serving a large community of users throughout the world.

What we have in mind are Earth Observatory Satellites three times the size of ERTS but in the same orbit. They will observe the weather and the oceans in addition to carrying out the Earth resources surveys first demonstrated by ERTS. Tentative plans, not yet approved by the President or Congress, call for us to launch our first Earth Observatory Satellite in 1978.

Various user groups are telling us now what they want these new satellites to do. You will be glad to know, I am sure, that there are able and dedicated people at the U. S. Geological Survey who are working hard to make sure that the images produced by these new observatories will be of such quality and accuracy that they can easily be processed into maps of the kind you are accustomed to working with.

There is not time today to discuss NASA's work in a related field -- the use of satellites to measure surface temperatures of the Earth on a global scale. Such measurements, for example, could be used to search for new sources of geothermal energy, that is, the so-called "hot spots".

We are becoming quite active in this field. We expect to have some interesting results from Skylab experiments in geothermal spotting over Utah and other Western states. In our new budget, which is now before Congress, we propose a new satellite to be launched in 1977 to make thermal measurements of the Earth's surface. This is called our Heat Capacity HCCM Mapping Mission satellite. Like ERTS, this is an experimental project, but we expect the technology employed will prove of major value in locating new mineral resources and energy sources and in mapping soils and geological formations.

Conclusion

When we launched ERTS-1, three years after the first men stepped upon the Moon, we took another giant stride for mankind -- here at home, in near Earth orbit. It was a step forward without high drama but with the highest significance for the future of all of us. With ERTS-1 we took a historic step that will help save the world as a habitable home for mankind. Read

The use of satellites for practical benefits, especially in the Rocky Mountain States, is just beginning. I am proud to have a part in this great effort, along with Senator Moss, and I hope we will have your support.

I thank you.

Dr. Fletcher, Conference of American Congress on Surveying and Mapping
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